Canada's Fraser River

Reasons for sockeye salmon declines with a comparison to Bristol Bay

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Introduction

Recently, Fraser River sockeye populations have been compared to those of Bristol Bay by proponents of mining projects in Bristol Bay, who cite Fraser River ... of 'coexistence' between mining and fisheries (Joling 2011). Due to ... and biological nature, as well as the vastly different levels of urbanization and industriali... the two systems make an unlikely comparison. However, the cu... River system with impaired water quality, human development, changes ... and prey bases, and climate change has resulted in the lowest productivity of ... sockeye in over fifty years.

Fraser River sockeye salmon populations are suffering from myriad ... with urban and industrial development, leading to dramatic decreases ... multiple fisheries closures, and federal and international population list... there are stressors from contamination (from mining, wood product ... facilities), introduced predators, and increased river temperatures. In the estuaries and ... marine environment, stressors are related to household and industrial ... of habitat, and warmer marine water temperatures.

While the blame for the declines simply cannot be pointed in ... current state of Fraser River sockeye is unfortunately another disast... co-existence of human development and salmon.

Status of Fraser River salmon

The Fraser River is known as one the greatest salmon rivers ... Canada's largest salmon producer (Burgner 1991). Sockeye salmon (*Oncorhynchus nerka*) ...

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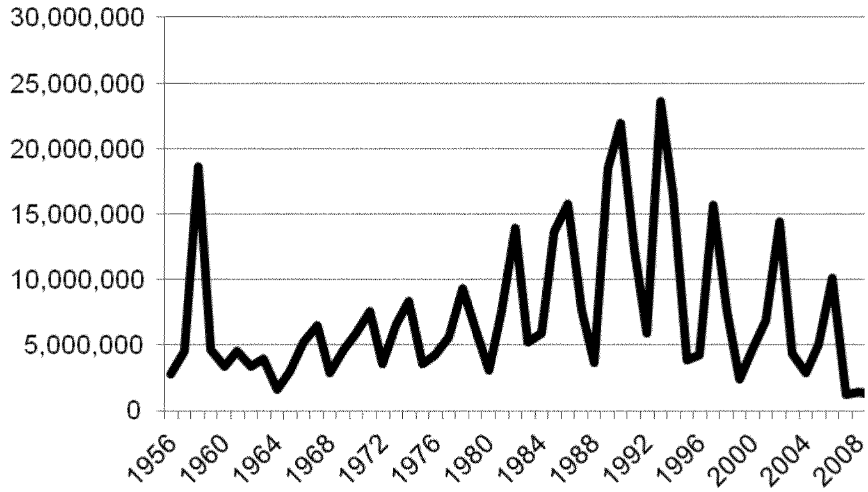
are the most commercially valuable species in the Fraser, and gener
millions of dollars annually until the mid 1990s (DFO 2011). In recent decades, h
total runs of sockeye, productivity (recruit per spawner), and comm
wide fluctuations, and ultimately significant declines (Pacific Salmon Co
2011). Productivity is currently low, indicating that populations are b
replacing themselves (Figure 1, Peterman et al. 2010). Low retu
closures in the last 6 of 11 years, including three consecutive
when total runs failed to exceed two million fish (Figure 1, P
data).



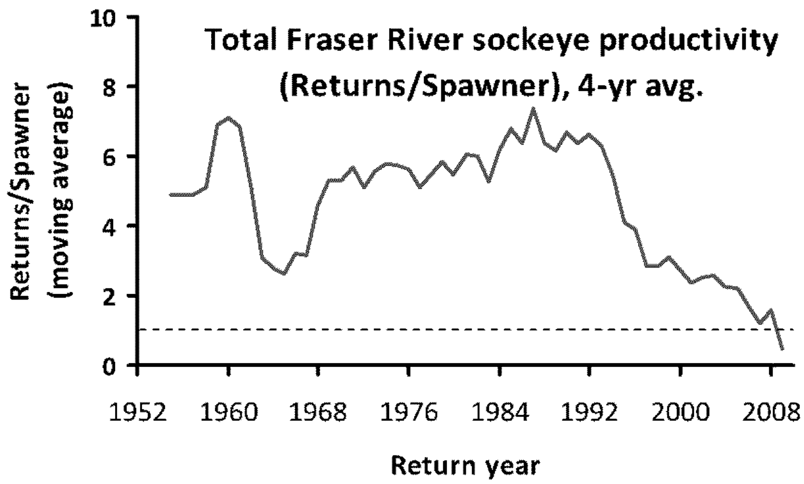


Figure 1. Total Fraser River sockeye returns (top) (year's harvest + escapem average of total adult returns per spawner across all Fraser River sockeye minor jacks component) divided by spawners 4 years before. The horizontal indicates the productivity at which the population can replace itself, i.e., re Salmon Commission data in Peterman et al. 2010.

During the most recent status review, the International Union for the
Conservation of Nature (IUCN) categorized 5 of 11 Fraser River
threatened: one as Critically Endangered, three as Endangered, and

(Rand 2008). Cultus Lake sockeye and the lower Fraser are designated
by the Canadian government Committee on the Status of Endangered
(COSWEIC; DFO 2011).

Prodigious research into causes of the declines includes an ongoing
federal judicial inquiry. To date, results suggest salmon and their
from a multitude of stressors. The following discussion summarizes
reviewed and gray literature on the Fraser River sockeye declines,
brief comparison of the Fraser River with the world's largest so
system, the Bristol Bay watershed in southwest Alaska. This dis
results emerge from the Cohen Commission federal inquiry, currently

Fraser River freshwater environment

Contaminants

MacDonald et al. (2011) systematically evaluated over 200 aquatic c
Fraser River basin in addition to potential exposure and harm to
study indicates contaminated water and sediment, as well as accumu
contaminants in fish tissue, could pose hazards to spawning, rearing
Primary elements of concern were pH, total suspended solids (TSS),
(nitrate, nitrite, and phosphorus), major ions (chloride, fluoride, and sulphate),
(aluminum, arsenic, boron, cadmium, chromium, cobalt, copper, iron, lea
selenium, and silver), and phenols. Concentrations of tetrachlorodibenzo-p-dioxin (TCDD) 2,3,7,8
equivalents occurred in salmon eggs at concentrations that may adv
reproduction. Data were insufficient to thoroughly examine impacts
disrupting chemicals such as pharmaceuticals, personal care products, i
pesticides, inorganic and organometallic compounds, and biogenic compounds
2008), though authors concluded they undoubtedly were entering the
likely have impacts on sockeye development and reproduction. For
occurrence of feminized sockeye salmon (MacDonald et al. 2011) is
exposure to endocrine disrupters.

Sources of contamination are numerous. Twenty eight major mines
placer mines, 10 pulp and paper mills, 90 sawmills, and other wood product mi
facilities, 15 wood preservation facilities, 17 cement and concrete fa
processing facilities, 37 municipal wastewater treatment plants, 37 salm
facilities (Appendix 1), 83 municipal landfills, and several manufacturing
facilities, as well as the oil and gas industry operate within t
2011). Many of the aforementioned facilities are permitted to discha
concern (MacDonald et al. 2011) and accidents occur. For instance, 51 spills
from various facilities during the period in 2007 (MacDonald et al.
2866 sites listed in Canada's Contaminated Sites Registry nearly 15
were located in the Fraser River watershed (MacDonald et al. 2011). Th
contaminated sites is currently estimated to exceed 5,000 (MacDonald

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Human activities also contribute non-point source pollution to the Fraser River. management activities, agricultural operations, and stormwater runoff can conta sediment, fertilizers, insecticides, fire retardants, and other contaminants 2011, Nelitz et al. 2011). MacDonald et al. (2011) indicate s suspended solids, nutrients, metals, phenols, and total hydrocarbons have the Fraser River from non-point sources. Finally atmospheric sources of pol persistent organic pollutants and mercury, which can also impact aq et al. 2005), include forest fires, volcanoes, and carbon emissions

Land Use

Nelitz et al. (2011) additionally examined impacts of mining, forestr hydroelectricity, urbanization, and water use on the freshwater environment and their potential impacts on Fraser River sockeye salmon populations.

Mining

Several types of mining take place in the Fraser Basin (Figure mining, industrial mineral production, metal mining, coal and gas pro mining. At least one operating mine, Gibraltar, produces acid m with high levels of dissolved copper and other metals, exceeding effluent discharge criteria by several orders of magnitude (Bra[illegible]gton and Ferguson 1987). Placer mining is dominant mining activity in the basi may have the most significant impac salmon due to sedimentation effects (Nelitz et al. 2011).

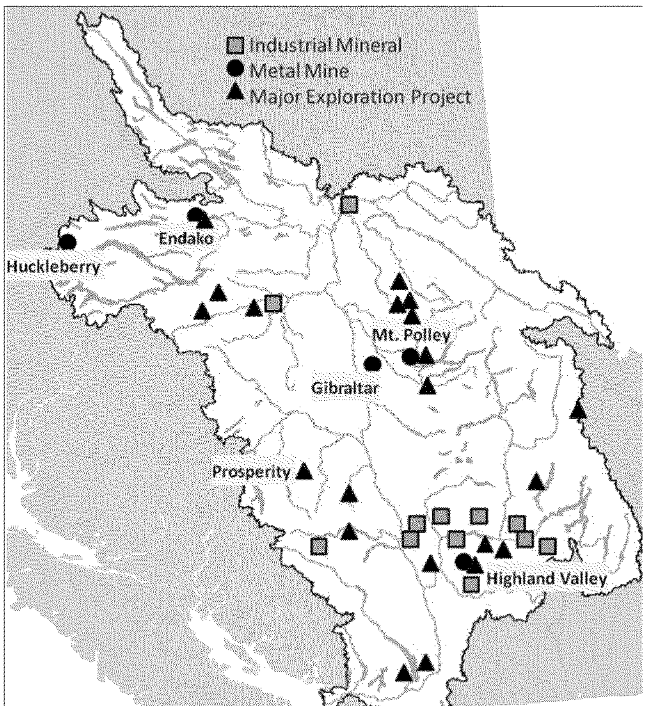

Figure 2. Distribution of the large mines in the Fraser River et al. 2011

Hydroelectric

Two large hydroelectric projects within the basin, the Bridge/Seton River power project and Alcan's Kemano Project Nechako River that affect water temperature and flow, at times inhib migration ability of sockeye salmon (Nelitz et al. 2001). Small s hydropower projects, which can affec Total Gas Pressure (usually nitrogen supersaturation), gravel supply, and wat temperature, also exist in the basein though in fairly low numbers (about Nelitz et al. 2011).

Urbanization

Water demand was associated with high human densities, large portion of … Fraser River basin. Population growth, associated with urbanization, wa… Fraser and 25% in municipalities upstream of Hope, British Columbia … years. Urbanization caused alterations to salmon habitat from impervious surfaces including roads, changes in hydrology, stream crossings and channelizat…

Forestry

While forest harvest has decreased significantly in recent decades, t… stream crossing per kilometer square in spawning areas and migration corridors … (MOE 2008). Road crossings often serve as barriers to fish … 1998), an integral aspect of the life history of anadromous salm… Further, up to 90% of watershed area was disturbed in some watersheds by Mountain Pine … infestation, potentially increasing fire risk and sedimentation as well … hydrology (Nelitz et al. 2011).

Agriculture

The land area occupied by agriculture has increased in recent years. Agriculture past… can cause physical alteration to streams, riparian zones, and floodpl… sedimentation and destabilize stream banks causing widening of stream… vegetation which can increase stream temperatures, subsequently compact increasing … runoff; dewater groundwater sources important to maintenance of strea… temperature regimes; increase biochemical oxygen demand; introduce patho… increase sedimentation, nutrients and contaminants through application of manure, fertilizers, and pesticides.

Predation

Predation of sockeye salmon occurs in both freshwater and marine … Christensen and Trites (2011) reviewed available literature on predatio… largemouth bass as well as yellow perch are introduced species in the water… known to feed on salmon species, but little data exists regarding… (Christensen and Trites 2011). Hatchery and wild salmon both … prey upon sockeye (Appendix 1, Kostow 2009, Tatara and Berejikian 20… 2011), although impacts are not well documented in the Fraser … enhancement facilities in the Fraser River Basin are listed below … to predation from hatchery fish, hatcheries are a source of potential … have additional negative ecological effects on wild salmon populations … al. 2009).

Climate Change

In British Columbia, minimum temperatures have increased 0.17°C per decade and precipitation has increased by 22% per century (Hinch and Martins 2011). Climate change has already caused earlier snowmelt in British Columbia rivers (Stewart et al. 2005), and water temperatures in the Fraser River have increased at a rate of 0.33°C per decade, increasing overall water temperature by about 2°C in the past 60 years (Chittendon et al. 2009). Lakes in the region are also warming, altering timing of spring ice break-up and lake turnover (Schindler et al. 2005).

Temperature related factors have also received a great deal of attention with respect to a marked increase in mortality during river migration and on spawning grounds (Hinch and Martins 2011).

> **Eggs**. Although sufficient data is lacking to thoroughly examine potential impacts of increased rainfall resulting from climate change, it is possible that increased rainfall is causing increased scour of redds, thereby decreasing overall egg survival (Hinch and Martins 2011).
>
> **Fry**. Temperature increases may be facilitating increased predation on lake-rearing sockeye fry (Hinch and Martins 2011).
>
> **Adult migrants**. Warmer river temperatures appear to decrease survival of adult migrants, particularly in early-run stocks, likely from a combination of exposure to temperatures above the 18 C thermal tolerance, increased energy required for migration at higher flows, and combined higher metabolism in elevated temperatures (Eliason et al. 2011, Hinch and Martins 2011). Pathogens including *Parvicapsula minibicornis* also develop more quickly in warmer temperatures (Cooke et al. 2004, Crossin et al. 2009), increasing physiological stress and decreasing swimming performance of adult migrants (Bradford et al. 2010, Wagner et al. 2005). Earlier migration timing, likely related to elevated temperatures, has coincided with en route and pre-spawning mortality exceeding 90% in some years, impacting larger stocks and pushing already threatened stocks such as Cultus Lake to near extinction (Cooke et al. 2004). These trends are expected to increase as climate change progresses (Hague et al. 2011, Rand et al. 2006).

Marine environment of the Fraser River

Contaminants

The Strait of Georgia is bordered by British Columbia's main pop
Vancouver and Victoria. About 80% of pollution is estimated to result th
disposal of liquid and solid waste from land-based activities (MOE 2006). Household
generate about two-thirds of that waste, while one-third is from industrial sources (M
2006). Despite vast increases in human populations of those areas (Johannes et al.
contaminants in the Strait of Georgia show a general improvement
management practices including recycling programs and secondary or b
treatment have improved in recent years (Johannes et al. 2011). In the p
polychlorinated biphenyls (PCBs), mercury, dioxins, butyltin and furans were tri
documented at much higher concentrations in waters, sediment, and
other biota in the Strait of Georgia (Johannes et al. 2011). Pulp and pape
shores of the Strait were a major contributor of contaminants at
effluent treatment improved. In recent decades, polybrominated dipher
care products and pharmaceuticals have increased in the Strait of Georg
2011).

Land/Marine Waters Use

Shipping and marine vessels transport most goods and services acro
be a source of noise, contaminants, oil spills, and introductions of
through ballast water exchange, though Johannes et al. (2011) concl
traffic has only limited direct interaction with sockeye habitat.
main navigation channel at the mouth of the Fraser River by three meters over the th
years, though dredging activities are limited to periods when sockey
estuary (FREMP 2006). Dikes are extensive throughout the low
causing an estimated 40% habitat loss in this area (Ellis et al. 2004), although their
construction has slowed in recent decades and some have been
habitat (Johannes et al. 2011).

Predation

Significant marine predators of Fraser River sockeye salmon may in[clude] spiny dogfish
(*Squalus acanthias*), salmon sharks (*Lamna ditropis*) and daggertooth (*Anotopterus nikparini*; Christensen and Trites 2011). Harbour seals (*Phoca vitulina richardsi*) and Steller
sea lions (*Eumetopias jubatus*) are also common predators and have increased dramatically
since their protection in 1970 under the Fisheries Act (Forrest et
Trites 2011). While Pacific herring (*Clupea pallasi*) and Pacific cod (*Gadus macrocephalus*) are unlikely to prey upon sockeye salmon, they are likely
competitor for food in the Strait of Georgia and have been in
decades (Christensen and Trites 2011).

Many native and introduced species in the Strait of Georgia also pre
with Fraser River sockeye salmon. The Strait hosts an estimated 117
more than twice the number found throughout the remainder of
result of human population growth, aquaculture, and shipping activities
2011). While available data is inconclusive, the recently documented Hu
(*Dosidicus gigas*; Cosgrove 2005) may prove to be significant predators of
(Christensen and Trites 2011).

Christensen and Trites (2011) indicate that data is insufficient to adequately identify
key predators of sockeye salmon and their overall impact, as we
critical cumulative impact of predation overall on sockeye in both
freshwater environments.

Climate Change

Major cycles associated with climate and sea surface temperature in
Ocean, the El Niño Southern Oscillation (ENSO) and the Pacific Decadal
have exhibited pattern changes in recent decades (Beamish 1999, Mantua et al. 1997
Marine habitat for Fraser River sockeye salmon, the Strait of Georgia

a a a a g a Chittenden et al. 2009 pH and salin
have decreased in the (IPCC 2007) Pacific. The period from 1980's to the late 1...
present experienced warmer conditions than those during the previous
1940 (Figure 3, Johannes et al. 2011). Sea surface temperature
1.5 °C in the past 60 years (Chittenden et al. 2009). Warm temperatures are coincident
with blooms of the *Heterosigma* algae. *Heterosigma* blooms can cause salmon
mortality through diminished respiratory function and ability to uptake
al. 2010).

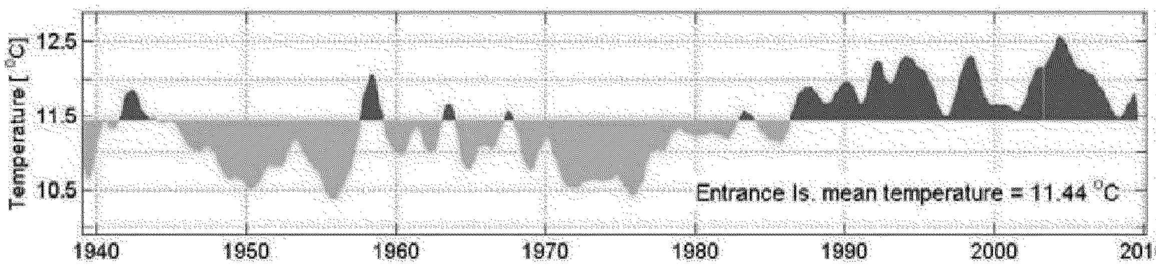

Figure 3. ... time series of monthly temperature anomalies from the long mean from 2010 ... from Entrance Island, central Strait of Georgia, BC (From

Temperature changes may also be causing a decline in zooplankton,
for rearing sockeye salmon (Figure 4, Johannes et al. 2011). Decline
taxa coincide with increases of other species which sockeye may
food quality is considerably lower with less fat content (El Sabaawi et al. 2009). Over
Johannes et al. (2011) conclude
that warming temperatures
coincide with declining
availability and quality,
may limit sockeye grow
decrease condition.

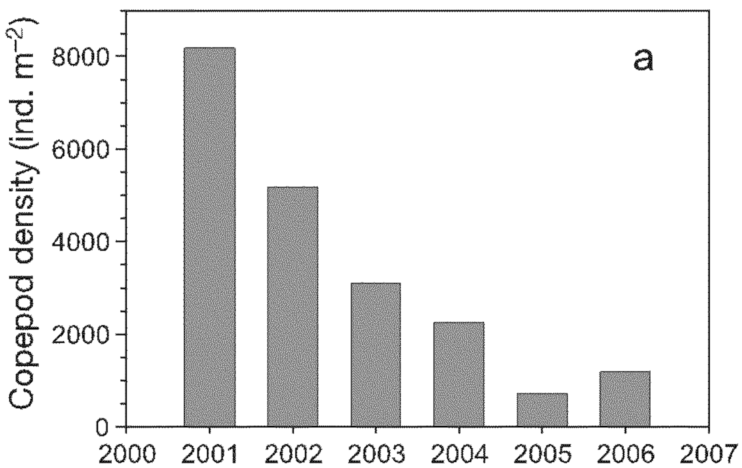

Figure 4. Declining zoop (*Neoclanus* sp.) abundance in Strait of Georgia. From Joha MacDonald 2009)

Fisheries Management

Fraser River Management

Management of Fraser River sockeye and other salmon falls under
Due to the international range of sockeye, marine the fishery is the subje

international Pacific Salmon Treaty between the U.S. and Canada an
six agencies (English et al. 2011).

Canada's main legal tool for sockeye salmon habitat conservation is
place since 1976. The Act is aimed to protect physical habitat
stages of sockeye, including their food sources and the quality o
live (Johannes et al. 2011). A "net gain" in overall acreage
through mitigation of development, restoration of lost or damaged habita
'enhancement' in the form of hatcheries and spawning channels.
and compensation projects have been ineffective (Wilson 2003), however hatcheries
have unintended, negative ecological impacts on sockeye salmon (see
2009).

Escapement targets, set annually under the Pacific Salmon Treaty by
are complicated by the cyclic nature of many Fraser River stocks resulting
variability in returns (English et al. 2011). Further, measurement
complicated by en route loss of sockeye (Figure 5). Escapement
the Early Stuart sockeye 2000 From 2005. While targets were met, English et
(2011) conclude that overharvest likely occurred in Early Stuart soc
and for Early Summer sockeye 1990 (Figure 6).

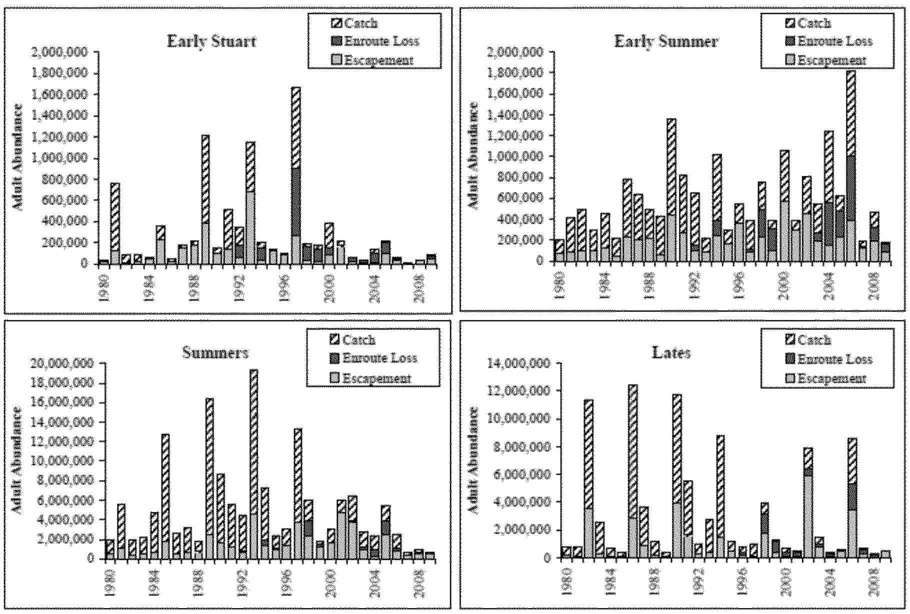

Figure 5. Estimates of total catch, escapement and en route loss of Fraser River sockeye by run group. En route losses were not estimated prior to 1992. From English et

Bristol Bay Management

English et al. (2011) reviewed differences in management structure
and the Fraser River and made the following conclusions. While the Fraser
to a complex, international management structure, management of Brist

entirely within the Alaska Department of Fish and Game and fou
Biologists. The simpler structure of Bristol Bay management allows for chan
regulations on a day-to-day basis during the fishing season, while manageme
require a much lengthier process for Fraser River sockeye. Mixe
also relatively minor in Bristol Bay due to the terminal nature of
districts for nine stocks, compared to the timing groups for Fraser River which four
consist of more than 25 stocks. Gear types are limited in Fraser
River. Further, due to relatively high escapement and low huma
Bay region, recreational and subsistence fisheries in Bristol Bay amo
total harvest, while First Nations and recreational catch allocations in the
densely populated Fraser River. Bristol Bay's sockeye runs are
with a typical season lasting six weeks compared to more than
River. Overall, Bristol Bay benefits from a 'portfolio' of many stocks and
history types exploiting multiple large, productive rivers, resulting in
fisheries closures (Schindler et al. 2010). In contrast, Fraser Riv
limited or closed in six of the last 20 years.

Wide fluctuations in sockeye returns to the Fraser River (Figure
adjust goals every year, resulting in overharvest of some stocks.
variability in returns allows Bristol Bay managers to use fixed escapement goals based o
maximum sustained yield principles. Finally, escapement estimates in
significantly more accurate than those in the Fraser River owing
counts and sonar upstream of each of the commercial fisheries in Bristol Bay vs. esse
one hydroacoustic site in the Fraser River) and the fact that
to the very high en route mortality, to which some (up to
subject to between enumeration and spawning grounds.

Influences on Bristol Bay and Fraser River sockeye

Due to their economic importance and historically high returns, Bris
River sockeye salmon have been compared in recent months. P
in Bristol Bay to use the Fraser River as an example of existing mining and
(Joling 2011). However, despite the watershed area of the Fraser Basin more
Bristol Bay's, Fraser River sockeye abundance pales in comparison (Figure
though the Kvichak River listing as a stock of concern (Morstad
sockeye are not currently experiencing the types of declines exhibite
Possible reasons for these differences abound, and a few are dis

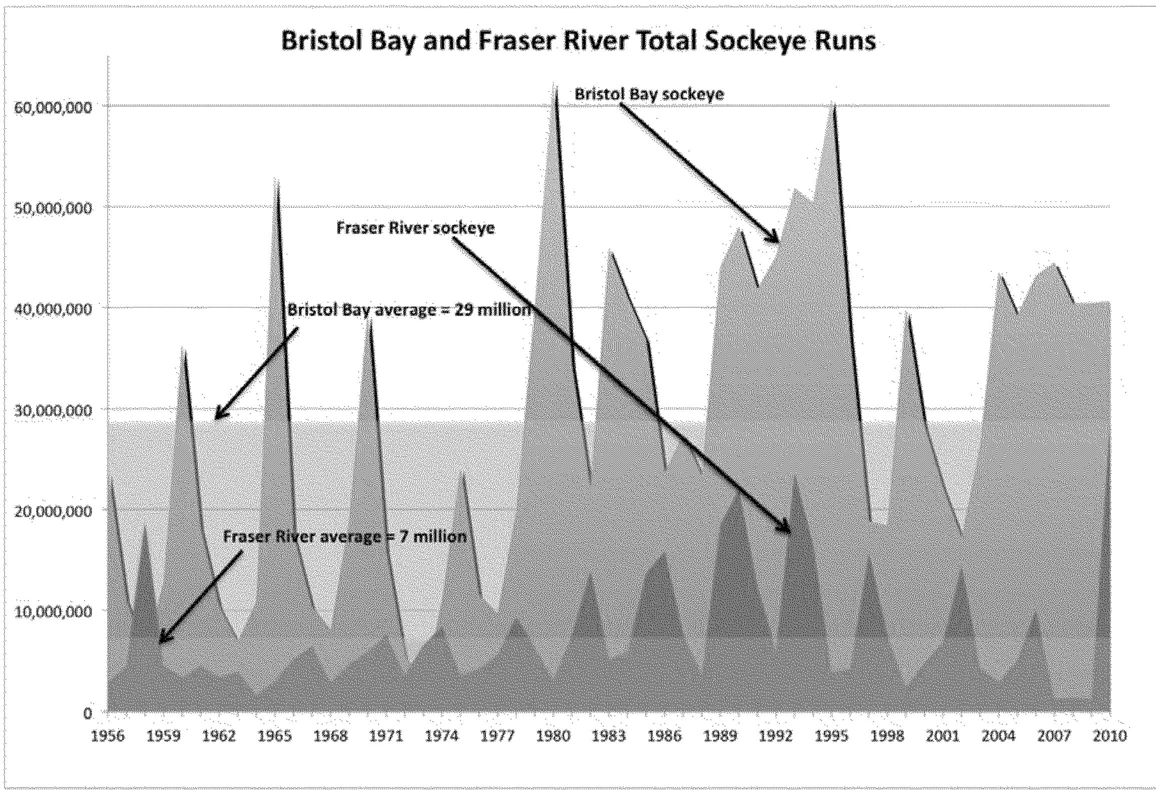

Figure 6. Bristol Bay (blue) and Fraser River (red) total runs (catch +
Averages for each river are indicated by shading. Data from ADFG 2010 and PSC

Habitat

Bristol Bay encompasses nine major watersheds and has a drainage area of a km² (FLBS 2011), while the Fraser River watershed drains 238,000 (Reynolds et al. 2006). Further, the two basins are subject to opposite trends Bristol Bay is experiencing high productivity, the Fraser River and other U rivers experience lower productivity, and vice versa (Mantua et al. 1997, Mantua and Hare 2002). The Bristol Bay basin was recently ranked as containing complex habitat throughout the range of Pacific salmon, making it more impacts of climate change (Mantua and Francis 2004, FLBS 2011) watersheds supporting salmon, including the Fraser River (FLBS 2011).

Aquaculture

In addition to management practices (reviewed by English et al. 2011), note that major aquaculture activities in the Fraser River basin a those in Bristol Bay, where aquaculture is prohibited. About 70 the migration route of Fraser River sockeye salmon (Price et al. research is controversial, farms have been associated with increased lice and disease (Price et al. 2011, Miller et al. 2011). Globally, marine survival abundance is reduced in areas supporting aquaculture (Ford and My

potential impacts to Fraser River sockeye from aquaculture activities
(www.cohencommission.com).

Further, in response to population declines of Fraser River sockeye, government operates nearly 30 hatcheries in the basin (MacDonald
1). Unintended effects of hatcheries include increased disease occurrence o
2007), direct predation of wild fish by hatchery fish (Naman and
competition for food resources (Dittman et al. 2011 in press) an
environment (Tatara et al. 2008), in estuaries (Daly et al. 2011), (Ruggerone et
al. 2011). The end result of competition is decreased productivi
2009). Bristol Bay does not support any salmon hatcheries, and
prohibited in the Bay and throughout the State of Alaska.

Human development

More than two-thirds of British Columbians live in the Fraser River
overall population of 2.73 million (BC President 2010 in Effects 2006). Effects of human act
including urbanization, forestry, mining, agriculture, introduction of contaminants, of non-
native species, and other factors are widely considered to be a
declines of salmon worldwide (Nehlsen et al. 1991, Hartman et al. 2000). Bristol Bay
currently supports only about seventeen small communities, and a population of less
5000 (DCRA 2010). At present, the region does not support major
human activity. In contrast to the water quality problems in
above, available data for waters in the Bristol Bay region indicate oxygenated, well
conditions with low concentrations of dissolved metals (Zamzow 2010 and other so

Cumulative impacts

The analysis conducted for the Cohen Commission is limited to
River sockeye declines within the past twenty years, during which declin
noticeable and commercially problematic (Pacific Salmon Commission data)
of the reports released to date conclude that existing baseline data and other
insufficient to thoroughly examine the factors in question (Cooke et
and Trites 2011, Hinch and Martin 2011, and others). The i
individual potential factors in declines, failing to consider the synerg
factors combined. Christensen and Trites (2011) conclude after the
of sockeye salmon that "Cumulative threats are far more difficult to evaluate
factor. In the case of Fraser River sockeye salmon, temperature stress fr
more in-kind competition due to increased escapement with resulting lo
running the gauntlet through predators whose alternative prey may
all have had cumulative effects. Assessing the cumulative effects of these and other
stresses will require integrated evaluation." Peterman et al. (2011) indicate
"should not necessarily expect to find a single dominant cause o
sockeye." Finally, Healey (in press), in a paper on predicting Fraser sockeye response to
climate change, indicates that the cumulative impacts of climate cha

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will which greater than the impacts on individual stressors. The concl
will also carry forward to the potentially leading to a downward
productive capacity, predicting a future for Fraser River sockeye salmon
major salmon rivers south of the coast where salmon are extirpated from 40%
of their former range (NRC 1996).

Conclusions

Fraser River sockeye salmon populations are suffering from a myria
associated with urban and industrial development, leading to dramatic
productivity, multiple fisheries closures, and federal population listings.

In freshwater, contamination from mining, wood product and other
wastewater treatment plants, landfills, and salmon enhancement facilities
and spawning channels) has a total of over 5000 sites, causing pro
with pH, TSS, turbidity, nutrients, metals, phenols, personal care pro
pharmaceuticals. Introduced predators such as yellow perch and sm
as hatchery fish may also impact sockeye in the Fraser River freshwater environmen
finally, increased river temperatures resulting from climate change are
higher mortality of sockeye en route to spawning grounds, likely
physiological stress at higher temperatures, decreased swimming efficiency, and fast
development of pathogens.

In the marine environment, industrialization and urban growth has
the Strait of Georgia by polybrominated diphenylethers, personal care
pharmaceuticals. Dredging and diking has reduced marine and estu
Increased ship traffic is associated with accidental spills, noise, and
native species. Warmer marine temperatures resulting from climate
with more frequent harmful algal blooms, resulting in lower oxygen
environment, as well as decreased zooplankton levels which are an
salmon food source.

Current efforts to understand Fraser sockeye declines are failing to
consider the synergistic effects of combined stressors such as contar
introduced predators, climate change, and others. Further, current a
rely upon inadequate historical datasets, which fail to satisfactorily define baseline
conditions.

Given their distinct physical and biological nature, as well as vas
urbanization and industrialization in the Fraser River basin relative
basin, recent comparisons between the two watersheds are suspect. Ho
comparing sockeye salmon populations alone, the world's largest sockeye
salmon producing system outnumbers the Fraser River by four times in
than half its size. The comparison between the two systems may
the inability of human development to coexist with salmon.

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Appendix 1. Salmon enhancement facilities in the Fraser River Basin. N/A = not available

Area of Interest/Facility Name	Facility Type	Species Targeted	Organization
Cultus Lake			
Chilliwack River Hatchery	Hatchery	Chinook, Coho, Chum, and Steelhead	DFO Operations
Fraser Valley Trout Hatchery	Hatchery	Native and Domestic Rainbow Trout, Anadromous and Coastal Cutthroat Trout, and Steelhead Trout	Freshwater Fisheries Society of BC
Centre Creek Streamkeeper Program	Hatchery	N/A	Public Involvement Programs (Volunteer)
Harrison River			
Chehalis River Hatchery	Hatchery	Coho, Chinook, Chum, Steelhead and Cutthroat Trout	DFO Operations
Weaver Creek Spawning Channel	Spawning Channel	Sockeye, Chum, Pink	DFO Operations
Fee Creek Spawning and Rearing Channel	Hatchery	Coho	Public Involvement Programs (Volunteer)
Lower Fraser River			
Inch Creek Hatchery	Hatchery	Coho, Chinook, Chum, and Steelhead Trout	DFO Operations
Bell-Irving Kanaka Creek Hatchery	Hatchery	Chum, Coho, Pink, Steelhead, and Cutthroat Trout	Public Involvement Programs (Volunteer)
Beecher Creek Streamkeepers	Hatchery	Coho, Cutthroat, and Rainbow Trout	Public Involvement Programs (Volunteer)
Al Grist Memorial Hatchery	Hatchery	Coho, Chinook, and Pink	Public Involvement Programs (Volunteer)
Chilliwack River Action Committee (Trap Site)	Hatchery	Steelhead Trout, Coho, Chinook, Chum, and Pink	Public Involvement Programs (Volunteer)
Stave Valley Salmonid Enhancement Society	Hatchery	Coho and Chum	Public Involvement Programs (Volunteer)
Nicomen Slough Spawning Channel	Hatchery	Coho and Chum	Public Involvement Programs (Volunteer)
Musqueam Creek Project	Hatchery	Coho, Chum, and Cutthroat Trout	Public Involvement Programs (Volunteer)
Steveston High School Hatchery (on-site)	Hatchery	Coho and Chinook	Public Involvement Programs (Volunteer)
Cougar Creek Salmonid Enhancement Group	Hatchery	Coho	Public Involvement Programs (Volunteer)
Hoy Creek Hatchery	Hatchery	Coho	Public Involvement Programs (Volunteer)
River Springs Salmon Enhancement and Stream keepers	Hatchery	Coho, Chum, and Chinook	Public Involvement Programs (Volunteer)

Area of Interest/Facility Name	Facility Type	Species Targeted	Organization
Lower Thompson River			
Spius Creek Hatchery	Hatchery	Chinook, Coho, and Steelhead Trout	DFO Operations
Loon Creek Hatchery	Hatchery	Rainbow Trout and Kokanee	Community Development Program Hatcheries
Deadman River Hatchery	Hatchery	Chinook and Coho	Community Development Program Hatcheries
Nechako River			
Nadina River Spawning Channel	Spawning Channel	Sockeye	DFO Operations
Spruce City Wildlife Fish Hatchery	Hatchery	Chinook	Public Involvement Programs (Volunteer)
North Thompson River			
Clearwater Trout Hatchery	Hatchery	Rainbow Trout and Kokanee Salmon	Freshwater Fisheries Society of BC
Dunn Lake Hatchery	Hatchery	Coho and Chinook	Community Development Program Hatcheries
Pitt River			
Upper Pitt River Hatchery	Hatchery	Chinook and Sockeye	DFO Operations
ALLCO Hatchery	Hatchery	Coho, Steelhead, Cutthroat, Pink, and Chinook	Public Involvement Programs (Volunteer)
Hyde Creek Hatchery	Hatchery	Coho and Chum	Public Involvement Programs (Volunteer)
Quesnel River			
Horsefly Spawning Channel	Spawning Channel	Sockeye	DFO Operations
Seton-Portage			
Gates Creek Spawning Channel	Spawning Channel	Pink	DFO Operations
Seton Creek Spawning Channels	Spawning Channel	Pink	DFO Operations
South Thompson River			
Shuswap River Hatchery	Hatchery	Chinook	DFO Operations
Kingfisher Community Hatchery	Hatchery	Coho, Spring, Sockeye, and Kokanee	Public Involvement Programs (Volunteer)
Adams River	Fishway	Sockeye	DFO Operations

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Area of Interest/Facility Name	Facility Type	Species Targeted	Organization
Upper Fraser River			
Penny Hatchery	Hatchery	Chinook	Community Development Program Hatcheries
Anderson Lake Fish Hatchery	Hatchery	Sockeye and Kokanee	Public Involvement Programs (Volunteer)
Hells Gate Fishways	Fishway	Sockeye, Coho, Pink, Chinook, Steelhead Trout	DFO Operations

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